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FUEL VAPOR PROCESSING SYSTEM

TECHNICAL FIELD

[001] The present invention relates to a fuel vapor processing system that processes fuel vapor produced in a fuel tank by forwarding it to a canister.

BACKGROUND OF THE INVENTION

[002] A conventional fuel vapor processing system for processing fuel vapor produced from an automotive fuel tank is illustrated in Figure 6. Such a system is disclosed for instance in Japanese patent application No. 2002-57054. In this system, an upper part of a fuel tank 1 communicates with a canister 2 via a fuel vapor passage 3. In this case, the upper part of the fuel tank 1 consists of two levels. The fuel tank end of the fuel vapor passage 3 is branched into a first branch passage 3a that communicates with the lower level of the fuel tank upper part and a second branch passage 3b that communicates with the upper level of the fuel tank upper part. The lower level of the fuel tank upper part is provided with a float valve 4 that communicates with the first branch passage 3a, and the upper level of the fuel tank upper part is provided with a cut valve 5 that communicates with the second branch passage 3b. The fuel tank 1 is additionally provided with a fill pipe 9 for conducting fuel from a fill nozzle G of a fuel pump into the fuel tank 1.

[003] The float valve 4 comprises a valve member 4a that starts floating on the fuel surface when the fuel tank 1 is filled nearly to full, and a port 4b provided at the corresponding end of the first branch passage 4a is closed by the valve member 4b when the fuel tank 1 is full. The cut valve 5 comprises a valve member 5a that floats on the fuel surface when the fuel tank 1 has tilted to a certain extent, and a port 5b provided at the corresponding end of the second branch passage 4b that is closed by the valve member 4b when it floats.

[004] A check valve 21 is provided in an intermediate point of the second branch

passage 3b. When the fuel tank 1 is filled to full and float valve 4 has closed the first branch passage 3a, this check valve 21 permits the internal pressure of the fuel tank 1 to rise to such an extent that the fuel level in the fill pipe 9 rises and activates a sensor of the fill nozzle G to automatically stop the supply of fuel from the nozzle G. When the internal pressure of the fuel tank 1 has risen beyond a prescribed level owing to the additional rise in the fuel surface level, the check valve 21 opens to conduct the fuel vapor to the canister 2 and prevents the fuel vapor from escaping out of the fill pipe 9.

[005] In such a fuel vapor processing system, because the rise in the internal pressure of the fuel tank 1 when the fuel tank 1 is filled full is relative small, the opening pressure of the check valve 21 is set relatively low so that the fuel vapor in the fuel tank 1 when it is filled full may be conducted to the canister 2 via the check valve 21, and absorbed by charcoal or other material filled in the canister 2. Thereby, when filling fuel into the fuel tank, the fuel vapor is prevented from escaping to the atmosphere via the fill pipe 9.

[006] Even when fuel is not being filled into the fuel tank 1, the internal pressure of the fuel tank 1 may rise if the fuel tank 1 is placed in a high temperature environment. In such a case also, the check valve 21 opens and allows the fuel vapor in the fuel tank 1 to be absorbed by the canister 2. When the surrounding temperature is high, a significant amount of fuel vapor can be produced. Therefore, the opening area of the check valve 21 is required to be large enough to accommodate a large flow rate of fuel vapor resulting from such an event.

[007] However, some of the existing fuel fill nozzles are equipped with a sensor that detects the rising of the froth or foam on the fuel surface in the fill pipe 9 to detect the tank full state and automatically stop the filling of fuel. When the opening area of the check valve 21 is increased as mentioned above, the opening of the check valve 21 may so rapidly stop the rise in the internal pressure of the fuel tank 1 that the froth fails to rise in the fill

pipe and the timing of detecting the tank full state may be delayed when a fuel nozzle equipped with such a sensor is used. Such a delay in detecting the tank full state may lead to spilling fuel.

BRIEF SUMMARY OF THE INVENTION

[008] In view of such problems of the prior art, a primary object of the present invention is to provide a fuel vapor processing system that can quickly remove any excessive internal pressure of a fuel tank without interfering with the capability of a sensor of a fuel fill nozzle to detect a tank full state.

[009] A second object of the present invention is to provide a fuel vapor processing system that can quickly release any remove internal pressure of a fuel tank without releasing the fuel vapor to the atmosphere.

[010] A third object of the present invention is to provide an improved fuel vapor processing system that can be installed without substantially altering the existing design.

[011] According to the present invention, at least one of these objects can be accomplished by providing a fuel vapor processing system, comprising: a fuel tank; a canister for absorbing fuel vapor produced from the fuel tank; a first passage communicating a nominal full level of the fuel tank at one end thereof with the canister at the other end thereof; a float valve provided at the fuel tank end of the first passage; a second passage communicating a part slightly higher than the nominal full level of the fuel tank at one end thereof with the canister at the other end thereof; a check valve provided at the fuel tank end of the second passage; wherein the check valve comprises a low set-pressure valve that opens at a first threshold pressure P1 substantially corresponding to a tank full state, a high set-pressure valve that opens at a second threshold pressure P2 higher than the first threshold pressure P1 and is connected in parallel with the low set-pressure valve, the high set-pressure valve being able to provide a larger flow rate than the low

set-pressure valve.

[012] Thus, the check valve operates in two stages so that the internal pressure of the fuel tank can be favorably controlled by the opening of the low set-pressure valve when the fuel tank is being filled to full so that the sensor associated with the fill nozzle can successfully detect a tank full state, and any excessive rise in the internal pressure of the fuel tank typically caused by a high temperature of the surrounding environment can be avoided by the opening of the high set-pressure valve. Therefore, the present invention can prevent the spilling of fuel that could be otherwise caused by the failure of the sensor to detect a tank full state, and releasing of fuel vapor from the fill pipe and excessive rise in the internal pressure of the fuel tank that could be otherwise cause by the failure of the check valve to conduct the fuel vapor to the canister at an adequate flow rate.

[013] The low set-pressure valve and high set-pressure valve may be disposed either coaxially to each other or laterally one next to the other. According to a preferred embodiment of the present invention, each of the low set-pressure valve and high set-pressure valve is provided with a valve chamber communicating with a canister end of the corresponding passage, a port communicating with a fuel tank end of the corresponding passage, a valve member adapted to selectively close the port, and a spring member resiliently urging the valve member against the port. A highly compact structure can be achieved when the valve member of the high set-pressure valve is cup-shaped, and defines the port of the low set-pressure valve in a bottom wall thereof, and the valve member and spring member of the low set-pressure valve is received inside the valve member of the high set-pressure valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[014] Now the present invention is described in the following with reference to the appended drawings, in which:

[015] Figure 1 is a schematic overall view of a fuel vapor processing system embodying the present invention;

[016] Figure 2 is an enlarged sectional view of the check valve;

[017] Figure 3a is a view similar to Figure 2 showing the state when the low set-pressure valve has opened;

[018] Figure 3b is a view similar to Figure 2 showing the state when the high set-pressure valve has also opened;

[019] Figure 4 is a view similar to Figure 2 showing a second embodiment of the present invention;

[020] Figure 5 is a graph showing an alternate relationship between the pressure and flow rate in the check valve; and

[021] Figure 6 is a schematic overall view of a conventional fuel vapor processing system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[022] Figure 1 is a diagram showing an overall structure of the fuel vapor processing system embodying the present invention, in which the parts corresponding to those of the prior art shown in Figure 6 are denoted with like numerals without repeating the description of such parts. Referring to Figure 1, a fuel tank 1 and a canister 2 are connected to each other via a fuel vapor passage 3, which is branched into a pair of branch passages 3a and 3b at the end communicating with the fuel tank 1. The first branch passage 3a is selectively closed by a float valve 4 provided at the fuel tank end of the first branch passage 3a, and the second branch passage 3b is selectively closed by a cut valve 5 provided at the fuel tank end of the second branch passage 3b.

[023] An intermediate part of the second branch passage 3b is provided with a two-stage check valve 6 which comprises a high set-pressure valve 7 and a low set-pressure valve 8

incorporated in the high set-pressure valve 7 as shown in Figure 2. The high set-pressure valve 7 comprises a valve chamber 7a communicating with the canister end of the second branch passage 3b, a port 7b communicating with the fuel tank end of the second branch passage 3b, a cup-shaped valve member 7c axially slidably received in the valve chamber 7a so as to selectively close the port 7b, and a compression coil spring 7d resiliently urging the valve member 7c in the direction to close the port 7b.

[024] The low set-pressure valve 8 comprises a cylindrical valve housing 8a formed inside the valve member 7c and integrally attached thereto, a port 8b formed in the bottom wall of the valve member 7c so as to communicate the valve housing 8a with the fuel tank end of the second branch passage 3b, a ball-shaped valve member 8c received in the valve housing 8a so as to selectively close the port 8b, and a compression coil spring 8d resiliently urging the valve member 8c in the direction to close the port 8b. The interior of the valve housing 8a communicates with the valve chamber 7a of the high set-pressure valve 7. The first prescribed pressure P1 at which the valve member 8c is pushed open against the spring force of the compression coil spring 8d is smaller than the second prescribed pressure P2 at which the valve member 7c is pushed open against the spring force of the compression coil spring 7d ($P1 < P2$).

[025] Under normal condition or when the internal pressure of the fuel tank 1 is not higher than that of the canister 2, the ports 7b and 8b of the check valve 6 are closed by the valve members 7c and 8c, respectively, as illustrated in Figure 2. When the fuel tank 1 is filled full, the first branch passage 3a is closed by the float valve 4, and any additional filling of fuel causes the internal pressure of the fuel tank 1 to rise. The resilient biasing force of the compression coil spring 8d is selected in such a manner that the pressure rise due to the filling of the fuel tank beyond the tank full state is enough to push open the valve member 8c against the spring force of the compression coil spring 8d. Therefore, when the

fuel tank is filled beyond the tank full state, the low set-pressure valve 8 opens (see Figure 3a).

[026]

Thus, the fuel vapor which is displaced from the fuel tank 1 by the filling of fuel into the fuel tank 1 beyond the tank full state is allowed to be conducted to the canister 2 as indicated by the arrows in Figure 3a, instead of the fuel fill pipe 9 so that the fuel vapor is successfully absorbed by the canister 2 and prevented from being released to the atmosphere from the fill pipe 9. By reducing the opening area of the port 8b, the flow rate of the fuel vapor directed to the canister 2 is controlled. Therefore, a certain level of pressure rise can be preserved in the fuel tank 1 so that the froth of fuel is allowed to rise in the fill pipe 9 during the time of filling the tank beyond the tank full state, and the sensor equipped to the fuel fill nozzle G is enabled to detect the rise of the froth and shut off the supply of fuel without any problem.

[027]

The internal pressure of the fuel tank 1 may rise to a significant level even when fuel is not being filled into the fuel tank 1 if the surrounding temperature is high. Such an excessive pressure is desired to be removed as soon as possible, but it is not desirable to release fuel vapor to the atmosphere to remove the high pressure. Such a pressure rise opens the low set-pressure valve 8, but the flow rate is so limited that the pressure rise may continue.

[028]

This problem is resolved by the high set-pressure valve 7 provided in the check valve 6. When the internal pressure of the fuel tank 1 reaches a prescribed pressure P2 higher than the set pressure P1 of the low set-pressure valve 8, this high set-pressure valve 7 opens. When the high set-pressure valve 7 opens, the vapor can flow across a relatively large sectional area surrounding the valve member 7c and the check valve 6 can thereby accommodate a relatively large flow rate in addition to that effected by the open state of the low set-pressure valve 8. As a result, even when the internal pressure of the fuel tank 1 rises

for other reasons than filling fuel into the fuel tank beyond the tank full state, the high pressure can be released to the canister 2 via the fuel vapor passage 3. The fuel vapor is absorbed by the canister 2, and would not be released to the atmosphere.

[029] The check valve 6 that opens in two stages as described above was made particularly compact by incorporating the low set-pressure valve 8 into the high set-pressure valve 7. Therefore, the check valve 6 can be mounted without requiring no more space than the conventional counterpart, and can also be used in place of a conventional counterpart without requiring any substantial change to the existing design.

[030] In the check valve 6 of the illustrated embodiment, the low set-pressure valve 8 was incorporated into the high set-pressure valve 7, but the check valve of the present invention is not limited to this example but may be designed in any other way possible as long as it combines a first valve that opens at a relatively low pressure and a second valve that opens at a relatively high pressure.

[031] Figure 4 shows another embodiment of the check valve 6. In Figure 4, the parts corresponding to those of the previous embodiment are denoted with like numerals without repeating the description of such parts. In this case, a low set-pressure valve 8 and high set-pressure valve 7 are arranged in parallel with each other. The bottom wall of the valve member 7c of the high set-pressure valve 7 is closed. The ports 7b and 8b of these valves on the side of the fuel tank 1 are commonly connected to the fuel tank end of the second branch passage 3b, and the valve chamber 7a and valve housing 8a of these valves on the side of the canister 2 are commonly connected to the canister end of the second branch passage 3b.

[032] This also provides an action similar to that of the previous embodiment by opening the low set-pressure valve 8 upon the occurrence of a slight pressure rise resulting from the filling of the fuel tank to full and opening the high set-pressure valve 7 upon the occurrence

of a substantial pressure rise resulting from a high temperature or a cause other than filling the tank full. According to this embodiment, because the two valves 7 and 8 can open independently from each other, the threshold pressures P1 and P2 can be set at a high precision, and the manufacturing process can be simplified.

[033] The low set-pressure valve 8 started opening at pressure P1 and the high set-pressure valve 7 started opening at pressure P2 in a step-wise fashion in the foregoing embodiment, but they may be adapted to open gradually so as to progressively increase the flow rate as the pressure rises as indicated by the graph of Figure 5. In the graph, the abscissa corresponds to the pressure (gauge pressure) inside the fuel tank 1, and the ordinate corresponds to the rate of flow that passes through the check valve 6. As indicated by the graph, the high set-pressure valve 7 and low set-pressure valve 8 remain closed when the pressure is lower than the first threshold pressure P1. Even in this state, there is a slight leak flow at the rate of Q1. When the pressure has reached the first threshold pressure P1, only the low set-pressure valve 8 opens, and the fuel vapor passes through the check valve 6 at a flow rate which progressively increases with the rise in the pressure. The increase flow rate eventually diminishes as the pressure approaches the second threshold pressure P2. When the pressure has reached the second threshold pressure P2, the high set-pressure valve 7 also opens, and the fuel vapor passes through the check valve 6 at the flow rate Q2. As the pressure rises further, the opening of the high set-pressure valve 7 progressive increases, and so does the flow rate. The second threshold pressure P2 should be selected to be equal to that encountered when the tank is filled full or slightly higher.

[034] By thus progressively increasing the flow rate with the rise in pressure, the canister can be absorb the fuel vapor from an early stage of filling up the fuel tank 1. Also, because the high set-pressure valve 7 is adapted to accommodate a relatively large flow rate for a given rise in pressure, the pressure rise owing to a high temperature condition can be

controlled in a relatively promptly.

[035]

Although the present invention has been described in terms of preferred embodiments thereof, it is obvious to a person skilled in the art that various alterations and modifications are possible without departing from the scope of the present invention which is set forth in the appended claims.